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TITLE: Multi-channel communications transceiver

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INVENTOR-INFORMATION:

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US-CL-CURRENT: 455/75, 455/314 , 455/423 , 455/84

CLAIMS:

We claim:

1. A transmission system, comprising: a baseband receiver to receiver a baseband signal from a transmitted signal; and one or more down-converting receivers that receive a signal in the transmitted signal that was transmitted in a corresponding one or more frequency separated transmission band.

2. The system of claim 1, wherein at least one of the down-converting receivers comprises: a down converter that converts the signal from the transmitted signal from the one of the plurality of transmission bands to a

base band; a filter coupled to receive signals from the down converter, the filter substantially filtering out signals not in the base band; an analog-to-digital converter coupled to receive signals from the filter and generate digitized signals; an equalizer coupled to receive the digitized signals.

3. The system of claim 2, wherein the down-converter creates an in-phase signal and a quadrature signal, the in-phase signal being the input signal multiplied by a cosine function at the frequency of the one of the plurality of transmission bands and the quadrature signal being the input signal multiplied by a sine function at the frequency of the one of the plurality of transmission bands.

4. The system of claim 2, wherein operating parameters of at least one of the down converter, the filter, the analog-to-digital converter, and the equalizer are adaptively chosen.

5. The system of claim 1, wherein the baseband receiver includes an analog processing circuit to receive an input signal; an analog-to-digital converter coupled to receive signals from the low-pass filter; and a data recovery block coupled to receive signals from the analog-to-digital converter.

6. The system of claim 5, wherein the analog processing circuit includes a low-pass filter.

7. The system of claim 5, wherein the analog processing circuit includes an amplifier.

8. The system of claim 5, wherein the analog processing circuit includes an

offset.

9. The system of claim 5, wherein the analog processing circuit receives
adaptively chosen parameters from an adaptive parameter control circuit.

10. The system of claim 5, wherein a digital circuit is coupled between the
analog to digital converter and the data recovery circuit.

11. The system of claim 10, wherein the digital circuit includes a digital
gain block.

12. The system of claim 10, wherein the digital circuit includes a digital
base-line correction block.

13. The system of claim 10, wherein the digital circuit includes an equalizer.

14. The system of claim 13, wherein the equalizer includes a decision feedback
equalizer.

15. The system of claim 13, wherein the equalizer includes a linear equalizer.

16. The system of claim 10, wherein the digital circuit receives at least one
parameter that is adaptively chosen in an adaptive parameter control circuit.

17. The system of claim 5, wherein the data recovery circuit is a slicer.

18. The system of claim 5, wherein the data recovery circuit includes a
forward error correction decoding circuit.

19. The system of claim 18, wherein the forward error correction decoding
circuit is a trellis decoder.

20. The system of claim 18, wherein the forward error correction decoding

circuit is a Reed-Solomon decoding circuit.

21. The system of claim 4, further including a descrambler circuit coupled to receive signals from the data recovery circuit.

22. The system of claim 1, further including a cross-channel interference correction circuit coupled between the one or more down-converting receivers.

23. The system of claim 22 wherein the cross-channel interference correction circuit corrects for interference between transmissions in the baseband and transmissions in the frequency separated transmission bands.

24. The system of claim 22 wherein the cross-channel interference correction circuit is further coupled to the baseband receiver to correct transmissions in the baseband for interference from transmissions in the frequency separated transmission bands.

25. The system of claim 1, further including a baseband transmitter that transmits data into the baseband; and one or more up-converting transmitters that transmit data into one of the frequency separated transmission bands.

26. The system of claim 25, wherein at least one of the up-converting transmitters includes a symbol mapper coupled to map a set of digital inputs to a symbol; and an up-conversion circuit coupled to form a transmission signal from the symbol at a carrier frequency.

27. The system of claim 25, further including a summer wherein the output signal from the up-converting transmitters is summed to form a sum signal.

28. The system of claim 27, further including a second

summer wherein the sum signal is summed with an output signal from the baseband transmitter to form the transmitted signal.

29. The system of claim 28, further including a high-pass filter coupled between the summer and the second summer to filter any base-band contribution out of the sum signal;

30. The system of claim 28, further including a low-pass filter coupled between the baseband transmitter and the second summer to filter any higher frequency component from the output signal from the baseband transmitter.

31. A method of transmitting data, comprising: receiving a transmitted signal from a transmission medium into a baseband receiver and one or more down-converting receivers; each of the down-converting receivers down-converting the transmission signal by a set carrier frequency to obtain a data signal for that down-converting receiver; and the baseband receiver receiving a data signal from the baseband of the transmitted signal.

32. The method of claim 31, further including forming a baseband signal in a baseband transmitter; forming one or more frequency separated signals in one or more up-converting transmitters; summing the baseband signal with the one or more frequency separated signals to form a sum signal; and transmitting the sum signal over the transmission medium to form the transmitted signal.

33. The method of claim 32, further including filtering a sum of the one or more frequency separated signals with a high pass filter before summing.

34. The method of claim 32, further including filtering the baseband signal
with a low pass filter before summing.

35. The method of claim 31, further including correcting for cross-channel
interference.

36. The method of claim 35, wherein correcting for cross-channel interference
includes correcting for interference between the down-converting receivers.

37. The method of claim 35, wherein correcting for cross-channel interference
includes correcting for interference between the down-converting receivers and
the baseband receiver.

38. The method of claim 35, wherein correcting for cross-channel interference
includes: receiving equalized signals from two or more of the baseband receiver
and the down-converting receivers; and subtracting components of the equalized
signals from two or more of the baseband receiver and the down-converting
receivers.

39. The method of claim 38, wherein subtracting components of the equalized
signals includes providing a transfer function between each pair of the two or
more of the baseband receiver and the down-converting receivers.

40. The method of claim 39 wherein coefficients of the transfer function are
adaptively chosen.

41. A transmission system, comprising: means for transmitting data into the
baseband and one or more frequency separated transmission bands on a
transmission medium; means for receiving data from the transmission medium.

42. A transceiver chip, comprising: a transmitter section, the transmitter section including a baseband transmitter that transmits data onto a transmission medium in a baseband channel, and one or more up-converting transmitters that transmits data onto the transmission medium in corresponding frequency separated channels; a receiver section, the receiver section including a baseband receiver that receives data from the transmission medium in the baseband channel, and one or more down-converting receivers that receive data from the transmission medium from the corresponding frequency separated channels.

43. The transceiver chip of claim 42, wherein the receiver section includes a cross-channel interference correction circuit.

44. The transceiver chip of claim 41, wherein the transmitter section includes a low-pass filter coupled to the base-band transmitter, a high-pass filter coupled to receive a summed output signal from the one or more up-converting transmitters, and a summer coupled to sum signals from the low-pass filter and the high-pass filter.

45. The transceiver chip of claim 41, wherein the baseband transmitter is a PAM transmitter.

46. The transceiver chip of claim 41, wherein the one or more up-converting transmitters includes a QAM transmitter.

47. The transceiver chip of claim 41, wherein the baseband transmitter is an 8-PAM transmitter with no error correction coding and the one or more up-converting transmitters are each 6/7 trellis encoded 128 QAM.

48. The transceiver chip of claim 41, wherein the baseband transmitter is a
16-PAM transmitter and the one or more up-converting transmitter includes a
16-QAM transmitter.

49. The transceiver chip of claim 41, wherein the baseband transmitter is a 16
PAM transmitter and the one or more up-converting transmitter includes a 32-QAM
transmitter.

50. The transceiver chip of claim 41, wherein the baseband transmitter is a
3/4 encoded 16 PAM transmitter and the one or more up-converting transmitter
includes a 6/7 encoded 128-QAM transmitter.

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TITLE: Multi-channel communications transceiver

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US-CL-CURRENT: 455/132, 375/219 , 375/260 , 375/298 , 455/103

CLAIMS:

We claim:

1. A transmission system, comprising: a baseband receiver to receiver a baseband signal from a transmitted signal; and one or more down-converting receivers that receive a signal in the transmitted signal that was transmitted in a corresponding one or more frequency separated transmission band.

2. The system of claim 1, wherein at least one of the down-converting receivers comprises: a down converter that converts the signal from the transmitted signal from the one of the plurality of

transmission bands to a
base band; a filter coupled to receive signals from the down converter, the
filter substantially filtering out signals not in the base band; an
analog-to-digital converter coupled to receive signals from the filter and
generate digitized signals; an equalizer coupled to receive the digitized
signals.

3. The system of claim 2, wherein the down-converter creates an in-phase
signal and a quadrature signal, the in-phase signal being the input signal
multiplied by a cosine function at the frequency of the one of the plurality of
transmission bands and the quadrature signal being the input signal multiplied
by a sine function at the frequency of the one of the plurality of transmission
bands.

4. The system of claim 2, wherein operating parameters of at least one of the
down converter, the filter, the analog-to-digital converter, and the equalizer
are adaptively chosen.

5. The system of claim 1, wherein the baseband receiver includes an analog
processing circuit to receive an input signal; an analog-to-digital converter
coupled to receive signals from the low-pass filter; and a data recovery block
coupled to receive signals from the analog-to-digital converter.

6. The system of claim 5, wherein the analog processing circuit includes a
low-pass filter.

7. The system of claim 5, wherein the analog processing circuit includes an
amplifier.

8. The system of claim 5, wherein the analog processing

circuit includes an
offset.

9. The system of claim 5, wherein the analog processing circuit receives
adaptively chosen parameters from an adaptive parameter control circuit.

10. The system of claim 5, wherein a digital circuit is coupled between the
analog to digital converter and the data recovery circuit.

11. The system of claim 10, wherein the digital circuit includes a digital
gain block.

12. The system of claim 10, wherein the digital circuit includes a digital
base-line correction block.

13. The system of claim 10, wherein the digital circuit includes an equalizer.

14. The system of claim 13, wherein the equalizer includes a decision feedback
equalizer.

15. The system of claim 13, wherein the equalizer includes a linear equalizer.

16. The system of claim 10, wherein the digital circuit receives at least one
parameter that is adaptively chosen in an adaptive parameter control circuit.

17. The system of claim 5, wherein the data recovery circuit is a slicer.

18. The system of claim 5, wherein the data recovery circuit includes a
forward error correction decoding circuit.

19. The system of claim 18, wherein the forward error correction decoding
circuit is a trellis decoder.

20. The system of claim 18, wherein the forward error

correction decoding
circuit is a Reed-Solomon decoding circuit.

21. The system of claim 4, further including a descrambler circuit coupled to receive signals from the data recovery circuit.

22. The system of claim 1, further including a cross-channel interference correction circuit coupled between the one or more down-converting receivers.

23. The system of claim 22 wherein the cross-channel interference correction circuit corrects for interference between transmissions in the baseband and transmissions in the frequency separated transmission bands.

24. The system of claim 22 wherein the cross-channel interference correction circuit is further coupled to the baseband receiver to correct transmissions in the baseband for interference from transmissions in the frequency separated transmission bands.

25. The system of claim 1, further including a baseband transmitter that transmits data into the baseband; and one or more up-converting transmitters that transmit data into one of the frequency separated transmission bands.

26. The system of claim 25, wherein at least one of the up-converting transmitters includes a symbol mapper coupled to map a set of digital inputs to a symbol; and an up-conversion circuit coupled to form a transmission signal from the symbol at a carrier frequency.

27. The system of claim 25, further including a summer wherein the output signal from the up-converting transmitters is summed to form a sum signal.

28. The system of claim 27, further including a second summer wherein the sum signal is summed with an output signal from the baseband transmitter to form the transmitted signal.

29. The system of claim 28, further including a high-pass filter coupled between the summer and the second summer to filter any base-band contribution out of the sum signal.

30. The system of claim 28, further including a low-pass filter coupled between the baseband transmitter and the second summer to filter any higher frequency component from the output signal from the baseband transmitter.

31. A method of transmitting data, comprising: receiving a transmitted signal from a transmission medium into a baseband receiver and one or more down-converting receivers; each of the down-converting receivers down-converting the transmission signal by a set carrier frequency to obtain a data signal for that down-converting receiver; and the baseband receiver receiving a data signal from the baseband of the transmitted signal.

32. The method of claim 31, further including forming a baseband signal in a baseband transmitter; forming one or more frequency separated signals in one or more up-converting transmitters; summing the baseband signal with the one or more frequency separated signals to form a sum signal; and transmitting the sum signal over the transmission medium to form the transmitted signal.

33. The method of claim 32, further including filtering a sum of the one or more frequency separated signals with a high pass filter before summing.

34. The method of claim 32, further including filtering the baseband signal
with a low pass filter before summing.

35. The method of claim 31, further including correcting for cross-channel
interference.

36. The method of claim 35, wherein correcting for cross-channel interference
includes correcting for interference between the down-converting receivers.

37. The method of claim 35, wherein correcting for cross-channel interference
includes correcting for interference between the down-converting receivers and
the baseband receiver.

38. The method of claim 35, wherein correcting for cross-channel interference
includes: receiving equalized signals from two or more of the baseband receiver
and the down-converting receivers; and subtracting components of the equalized
signals from two or more of the baseband receiver and the down-converting
receivers.

39. The method of claim 38, wherein subtracting components of the equalized
signals includes providing a transfer function between each pair of the two or
more of the baseband receiver and the down-converting receivers.

40. The method of claim 39 wherein coefficients of the transfer function are
adaptively chosen.

41. A transmission system, comprising: means for transmitting data into the
baseband and one or more frequency separated transmission bands on a
transmission medium; means for receiving data from the transmission medium.

42. A transceiver chip, comprising: a transmitter section, the transmitter section including a baseband transmitter that transmits data onto a transmission medium in a baseband channel, and one or more up-converting transmitters that transmits data onto the transmission medium in corresponding frequency separated channels; a receiver section, the receiver section including a baseband receiver that receives data from the transmission medium in the baseband channel, and one or more down-converting receivers that receive data from the transmission medium from the corresponding frequency separated channels.

43. The transceiver chip of claim 42, wherein the receiver section includes a cross-channel interference correction circuit.

44. The transceiver chip of claim 41, wherein the transmitter section includes a low-pass filter coupled to the base-band transmitter, a high-pass filter coupled to receive a summed output signal from the one or more up-converting transmitters, and a summer coupled to sum signals from the low-pass filter and the high-pass filter.

45. The transceiver chip of claim 41, wherein the baseband transmitter is a PAM transmitter.

46. The transceiver chip of claim 41, wherein the one or more up-converting transmitters includes a QAM transmitter.

47. The transceiver chip of claim 41, wherein the baseband transmitter is an 8-PAM transmitter with no error correction coding and the one or more up-converting transmitters are each 6/7 trellis encoded 128 QAM.

48. The transceiver chip of claim 41, wherein the baseband transmitter is a
16-PAM transmitter and the one or more up-converting transmitter includes a
16-QAM transmitter.

49. The transceiver chip of claim 41, wherein the baseband transmitter is a 16
PAM transmitter and the one or more up-converting transmitter includes a 32-QAM
transmitter.

50. The transceiver chip of claim 41, wherein the baseband transmitter is a
3/4 encoded 16 PAM transmitter and the one or more up-converting transmitter
includes a 6/7 encoded 128-QAM transmitter.

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TITLE: 10165368High-speed multi-channel communications transceiver with inter-channel interference filter

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Sallaway, Peter J.	San Diego	CA	US	
Taylor, Gerard E.	Laguna Nigel	CA	US	

US-CL-CURRENT: 455/423

CLAIMS:

We claim:

1. A transmission system, comprising: a plurality of receivers, each of the plurality of receivers receiving signals from one of a plurality of transmission bands; and a cross-channel interference canceller coupled to the plurality of receivers.

2. The system of claim 1, wherein at least one of the plurality of receivers comprises: a down converter that converts an input signal from the one of the plurality of transmission bands to a base band; a filter

coupled to receive
signals from the down converter, the filter substantially filtering out signals
not in the base band; an analog-to-digital converter coupled to receive
signals from the filter and generate digitized signals; an equalizer coupled
to receive the digitized signals; and a trellis decoder coupled to receive
signals from the equalizer and generate recreated data, the recreated data
being substantially the same data transmitted by a corresponding transmitter.

3. The system of claim 2, wherein the down-converter creates an in-phase
signal and a quadrature signal, the in-phase signal being the input signal
multiplied by a cosine function at the frequency of the one of the plurality of
transmission bands and the quadrature signal being the input signal multiplied
by a sine function at the frequency of the one of the plurality of transmission
bands.

4. The system of claim 3, wherein the filter includes an in-phase filter
filtering the in-phase signal and a quadrature filter filtering the quadrature
signal.

5. The system of claim 3, further including an offset block coupled between
the down-converter and the filter, the offset block offsetting the in-phase
signal and the quadrature signal such that signals output from the
analog-to-digital converter averages zero.

6. The system of claim 3, further including an amplifier coupled between the
filter and the analog-to-digital converter, the amplifier amplifying an
in-phase filtered signal from the in-phase filter and a quadrature filter
signal from the quadrature filter such that the

analog-to-digital converter is
filled.

7. The system of claim 6, wherein an in-phase gain of the amplifier and the
quadrature gain of the amplifier are adaptively chosen in an automatic gain
controller.

8. The system of claim 7, wherein the automatic gain controller sets the
in-phase gain and the quadrature gain based on the digitized signals from the
analog to digital converters.

9. The system of claim 8, wherein the in-phase gain and the quadrature gain
are equal.

10. The system of claim 3, wherein the analog-to-digital converter includes a
first analog-to-digital converter coupled to receive signals from the in-phase
filter and a second analog-to-digital converter coupled to receive signals from
the quadrature filter.

11. The system of claim 12, further including a correction circuit coupled
between the analog-to-digital converter and the equalizer.

12. The system of claim 11, wherein the correction circuit includes an
adjustment to correct phases between the in-phase signal and the quadrature
signal.

13. The system of claim 12, wherein a small portion of one of the in-phase
signal and the quadrature signal are added to the opposite one of the in-phase
signal and the quadrature signal.

14. The system of claim 13, wherein a second portion of the opposite one of
the in-phase signal and the quadrature signal is added to the opposite one of

the in-phase signal and the quadrature signal.

15. The system of claim 14, wherein the small portion and the second portion are adaptively chosen.

16. The system of claim 15, wherein the small portion is a function of in-phase and quadrature output signals from the correction circuit.

17. The system of claim 16, wherein the second portion is a function of the ratio between in-phase and quadrature signals from the correction circuit.

18. The system of claim 3, wherein a phase rotator circuit is coupled between the analog-to-digital converter and the equalizer.

19. The system of claim 18, wherein a parameter of the phase rotator circuit is adaptively chosen.

20. The system of claim 3, wherein an amplifier is coupled between the equalizer and the trellis decoder.

21. The system of claim 20, wherein a quadrature correction is coupled between the amplifier and the trellis decoder.

22. The system of claim 21, wherein an offset circuit is coupled between the quadrature correction and the trellis decoder.

23. The system of claim 20, wherein an in-phase gain and a quadrature gain of the amplifier are adaptively chosen from error signals calculated from sliced values.

24. The system of claim 23, wherein the sliced values are determined from input signals to the trellis decoder.

25. The system of claim 21, wherein a parameter of the

quadrature correction
is adaptively chosen.

26. The system of claim 22, wherein a parameter of the offset circuit is
adaptively chosen.

27. The system of claim 2, wherein the equalizer is a complex equalizer
executing a transfer function, the transfer function having parameters
C.sub.k.sup.x(j) and C.sub.k.sup.y(j) where j is an integer.

28. The system of claim 2, wherein the equalizer is a complex equalizer
executing a transfer function, the transfer function having parameters
C.sub.k.sup.x,I(n), C.sub.k.sup.y,I(n), C.sub.k.sup.x,Q(n) and
C.sub.k.sup.y,Q(n), where n is an integer indicating the clock cycle, and k is
an integer indicating the channel.

29. The system of claim 27, wherein the center parameters C.sub.k.sup.x(0) and
C.sub.k.sup.y(0) are fixed.

30. The system of claim 29, wherein C.sub.k.sup.x(0) is one and
C.sub.k.sup.y(0) is zero.

31. The system of claim 29, wherein the parameters C.sub.k.sup.x(-1) and
C.sub.k.sup.y(-1) are fixed.

32. The system of claim 1, wherein the cross-channel interference canceller
provides transfer functions coupled between pairs of channels so that each of
the plurality of channels can be corrected for cross-channel interference.

33. The system of claim 32, wherein the transfer functions includes one or
more time delays.

34. The system of claim 32, wherein coefficients of the transfer functions are adaptively chosen.

35. The system of claim 1, wherein an operating frequency of the plurality of receivers is adjusted to match that of a corresponding plurality of transmitters transmitting data into the transmission bands.

36. A method of transmitting data, comprising: receiving a transmitted signal from a transmission medium into a plurality of receivers; each of the plurality of receivers down-converting the transmission signal by a set carrier frequency; and cancelling the cross-channel interference in each of the plurality of receivers.

37. The method of claim 36, wherein cancelling the cross-channel interference in each of the plurality of receivers includes: receiving equalized signals from each of the plurality of receivers; and subtracting components of the equalized signals from each of the plurality of receivers from each of the other receivers.

38. The method of claim 37, wherein subtracting components of the equalized signals includes providing a transfer function between each of the plurality of receivers.

39. The method of claim 38, wherein the transfer function includes a multi-tap transfer function.

40. The method of claim 39 wherein coefficients of the transfer function are adaptively chosen.

41. A transmission system, comprising: means for transmitting data into multiple channels on a transmission medium, each of the

multiple channels
having a carrier frequency; means for receiving data from the transmission
medium; means of down-converting data from each of the multiple channels;
means for digitizing the data from each of the multiple channels; means for
equalizing the data from each of the multiple channels to correct for
intersymbol interference; means for correcting the data from each of the
multiple channels for cross-channel interference; and means for providing
recovered data based on the corrected and equalized data from each of the
multiple channels.